Integrated Monetary and Financial Policies for Small Open Economies

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Motivation

- Many small open economies follow more eclectic approaches than textbook inflation targeting
  $\Rightarrow$ But the eclectic approach lacks a framework
- Goal is provide a framework to guide the optimal use of central bank tools:
  - Monetary policy and exchange rate flexibility
  - Capital controls
  - FX intervention
  - Macroprudential policies
- Build an integrated model with multiple externalities and ask:
  - How do the entire range of policies and externalities interact?
  - How do the tradeoffs change when policies are used in combinations?
  - How should countries optimally use these policies?

Related Literature

- Pricing paradigm
  - Gali and Monacelli (2005), Gopinath (2015), Casas et al. (2016), Egorov and Mukhin (2019), Gopinath et al. (2020).
- Capital controls
  - Mendoza (2010), Jeanne and Korinek (2010), Bianchi (2011), Farhi and Werning (2014), Farhi and Werning (2016)
- FX intervention
  - Gabaix and Maggiori (2015), Fanelli and Straub (2019), Cavallino (2019)
- Macroprudential policies
  - Kiyotaki and Moore (1997), Korinek and Sandri (2016), Caballero and Krishnamurthy (2001)

Preview of results

1. Prudential capital controls depend on pricing paradigm
   - Capital controls optimal for lower initial debt under dominant currency pricing
2. Trilemma and dilemma: Capital controls and FX intervention enhance monetary autonomy if FX markets are shallow
3. Emerging market conundrum: Limits on currency mismatches can make FX markets shallower
4. Depreciations relax housing constraint but tighten external FX constraints

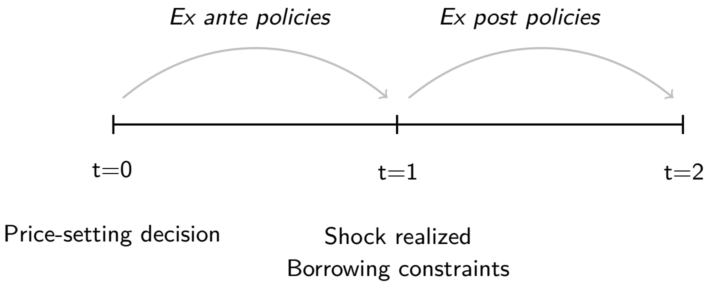
Roadmap

- Motivation
- Preview of results
- Environment
- Result 1: Capital controls and pricing paradigm
- Result 2: Monetary autonomy with shallow FX markets
- Result 3: Currency mismatch regulations and FX market depth
- Result 4: Domestic versus external constraints
- Conclusion

Environment

- **Policy tools:** policy rate, capital controls, FX intervention, consumer and housing macroprudential taxes

- **Sectors:** households, tradable goods firms, housing firms, domestic banks, international financial intermediaries



Households

- Cole and Obstfeld (1991)

$$\max \mathbb{E}_0 \sum_{t=0}^{2} \beta^t \left[\alpha_H \log C_{Ht} + \alpha_F \log C_{Ft} + \alpha_R \log C_{Rt} - N_t\right]$$

- Budget constraint:

$$\underbrace{W_t N_t}_{\text{wages}} + \underbrace{E_t P^*_{Zt} Z_t}_{\text{commodity}} + \underbrace{\sum{}_j \Pi_{jt} + \sum{}_k T_{kt}}_{\text{profits and rebates}} + \underbrace{D_{HHt+1}}_{\text{debt}}$$
$$\geq \underbrace{P_H C_{Ht}}_{\text{home goods}} + \underbrace{E_t P^*_{Ft} C_{Ft}}_{\text{imports}} + \underbrace{P_{Rt} C_{Rt}}_{\text{housing}} + \underbrace{(1+\theta_{HHt-1})}_{\text{consumer tax}} \underbrace{(1+\rho_{t-1})}_{\text{borrowing rate}} D_{HHt}$$

- FOCs:

$$C_{Ht} = \frac{\alpha_H}{\alpha_F} \frac{E_t P^*_{Ft}}{P_H} C_{Ft}, \; W_t = \frac{1}{\alpha_F} E_t P^*_{Ft} C_{Ft}, \text{ and } C_{Rt} = \frac{\alpha_R}{\alpha_F} \frac{E_t P^*_{Ft}}{P_{Rt}} C_{Ft}$$

$$\frac{\alpha_F}{P^*_{Ft} C_{Ft}} = \beta \left(1+\theta_{HHt}\right)\left(1+\rho_t\right) \mathbb{E}_t \left[\frac{E_t}{E_{t+1}} \frac{\alpha_F}{P^*_{Ft+1} C_{Ft+1}}\right]$$

Tradable goods firms

- Gali and Monacelli (2005), Gopinath et al. (2020)

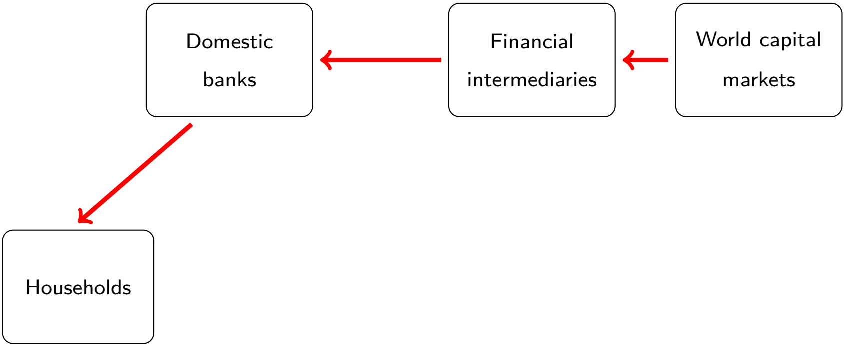
$$Y_{Ht}(j) + Y_{Xt}(j) = A_t N_t(j)$$

$$Y_{Ht}(j) = \left(\frac{P_H(j)}{P_H}\right)^{-\varepsilon} \underbrace{Y_{Ht}}_{\text{home consumption}} \text{ and } Y_{Xt}(j) = \left(\frac{P_X(j)}{P_X}\right)^{-\varepsilon} \underbrace{Y_{Xt}}_{\text{exports}}$$

$$Y_{Xt} = \omega p_{Xt} C_t^* \text{ where } p_{Xt}^{PCP} = \frac{E_t P_{Ft}^*}{P_H} \text{ and } p_{Xt}^{DCP} = \frac{P_{Ft}^*}{P_X}$$

- PCP: Set P_H
- DCP: Set P_H and $P_X = P_X\left(P_H, \{C_{Ft}\}, \{E_t\}\right)$

External constraint and capital controls



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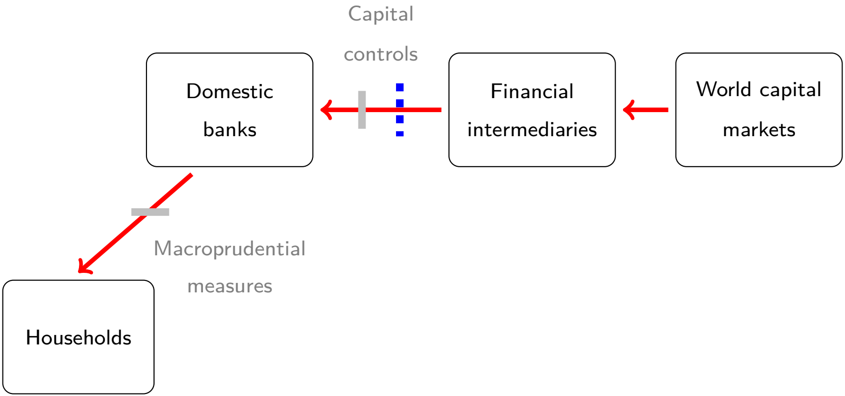


Domestic banks

- Mendoza (2010), Jeanne and Korinek (2010), Bianchi (2011), Farhi and Werning (2016)

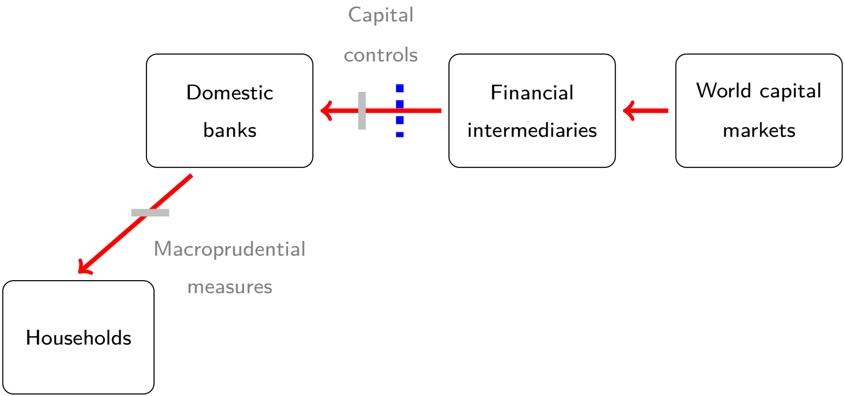
- External constraint:

$$D_2 = D_{HH2} + D_{R2} \leq \kappa_{H1} P_H \text{ and } \rho_t \geq i_t$$

$$\Rightarrow B_2 \leq \kappa_{H1} \frac{P_H}{E_1}$$

- Financial intermediaries receive $(1 - \varphi_t)(1 + i_t)$ from banks

Intermediation friction and FX intervention



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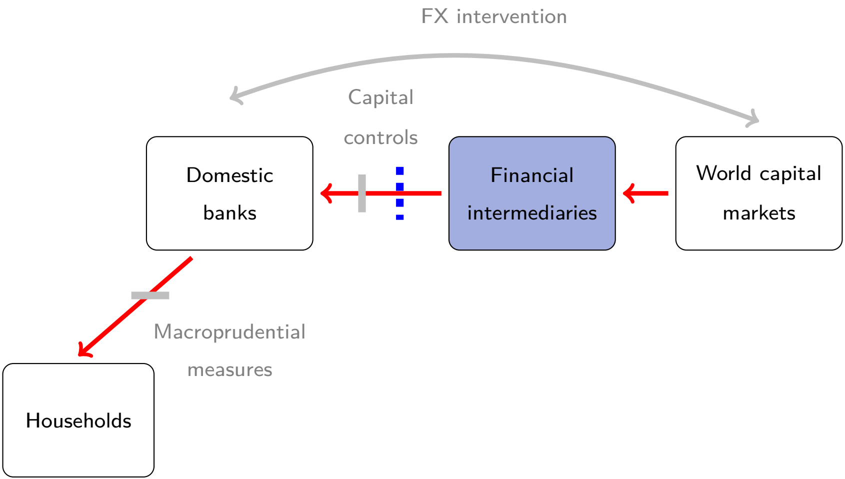


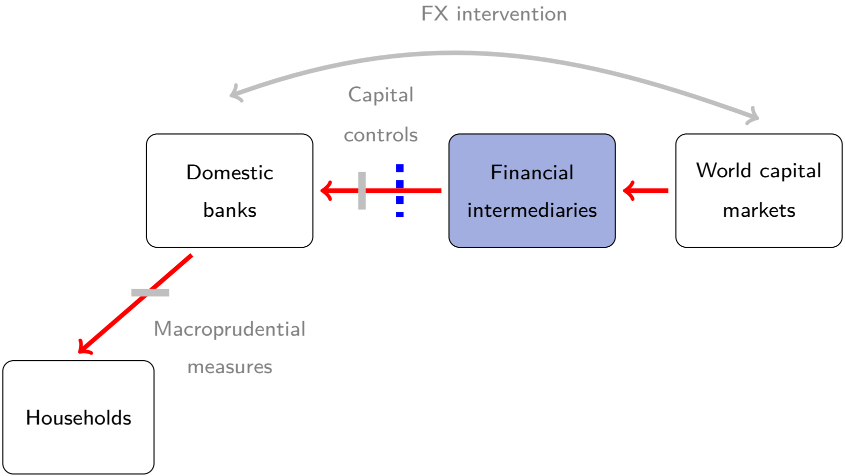
Financial intermediaries

- Gabaix and Maggiori (2015)

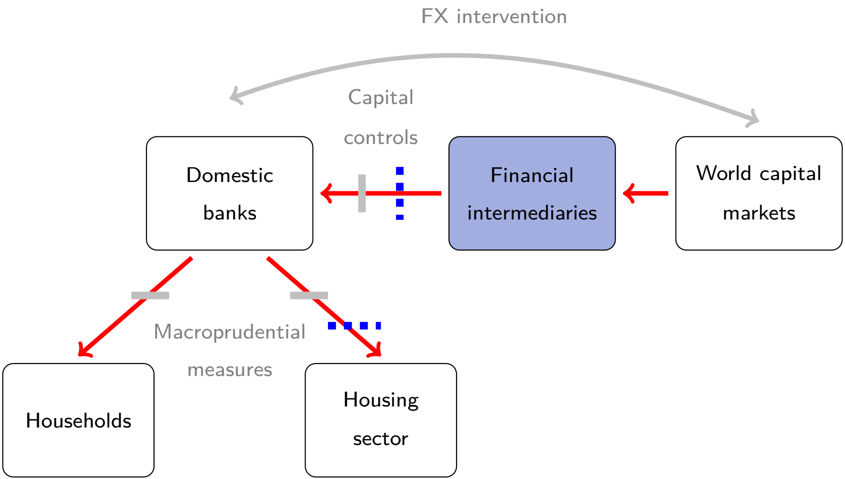
$$\Gamma\left(B_{t+1} + FXI_t - S_t\right) = \mathbb{E}_t[\underbrace{(1-\varphi_t)\left(1+i_t\right)\frac{E_t}{E_{t+1}}}_{\eta_{t+1}} - (1+i_t^*)]$$

- $\lambda \in [0,1]$ of them are owned by domestic households $\Rightarrow$ currency mismatch

Fire sales and housing regulation



Fire sales and housing regulation



Housing firms

- Kiyotaki and Moore (1997)

- FOC of linear subsector:

$$\frac{\mathbb{E}_t\left[P_{Rt+1}+q_{t+1}\right]}{\left(1+\theta_{Rt}^{Linear}\right)\left(1+\rho_t\right)} \geq q_t$$

$$D_{R2}^{Linear} \leq \kappa_{L1} q_{L1} L_1^{Linear}$$

- FOC of concave subsector:

$$\frac{G'\left(L_t^{Concave}\right)\mathbb{E}_t\left[P_{Rt+1}\right]+\mathbb{E}_t\left[q_{t+1}\right]}{\left(1+\rho_t\right)} = q_t$$

- Market clearing: $L_t^{Linear} + L_t^{Concave} = 1$ and $C_{Rt} = Y_{Rt+1}^{Linear} + Y_{Rt+1}^{Concave}$

Social planner's problem

Characterize constrained efficient allocations

$$\max_{\left\{C_{Ft}, P_H, E_t, \eta_{t+1}, FXI_t, L_{t-1}^{Linear}\right\}} \mathbb{E}_0 \left[\sum_{t=0}^{2} \beta^t V\left(C_{Ft}, \frac{E_t P_{Ft}^*}{P_H}, \frac{P_{Ft}^*}{P_{\$t}}, L_{t-1}^{Linear} \right) \right]$$

Pricing paradigm: $P_{\$t} = \frac{P_H}{E_t}$ if PCP; $P_{\$t} = P_X\left(\{C_{Ft}\}, \{E_t\}, P_H\right)$ if DCP

Resource constraint:

$$\left(1+i_{-1}^*\right) B_0 \leq \sum_{t=0}^{2} \frac{P_{Ft}^*\left[\omega C_t^* - C_{Ft}\right] + P_{Zt}^* Z_t - (1-\lambda) FXI_{t-1}\left[\eta_t - \left(1+i_{t-1}^*\right)\right]}{\Pi_{s=1}^{t}\left[\lambda\left(1+i_{s-1}^*\right) + (1-\lambda)\eta_s\right]}$$

Housing firms' borrowing constraint: $B_{R2}^{Linear} \leq \kappa_{L1} \frac{q_{L1}}{E_1} L_1^{Linear}$

Domestic banks' borrowing constraint: $B_2 \leq \kappa_{H1} \frac{P_H}{E_1}$

Intermediary friction: $\Gamma\left(B_{t+1} + FXI_t - S_t\right) = \mathbb{E}_t\left[\eta_{t+1} - \left(1+i_t^*\right)\right]$

Wedges and externalities

- Optimal policies depend on the following wedges:

$$\text{AD wedge} = \frac{C_{Ht}}{\alpha_H}\left(\frac{\alpha_H}{C_{Ht}} - \frac{1}{A_t}\right) \qquad \text{UIP wedge} = \left[\eta_t - (1 + i^*_{t-1})\right]\frac{\alpha_F}{P^*_{Ft} C_{Ft}}$$

$$\text{TOT wedge} = -p_{Xt}\frac{C_{Ft}}{\alpha_F}\frac{1}{A_t} \qquad \text{Housing wedge} = \left[1 - G'\left(1 - L^{Linear}_{t-1}\right)\right]\frac{\alpha_R}{C_{Rt}}$$

- AD externality: households do not internalize impact of decisions on AD
- Pecuniary AD externality: households do not internalize impact on bank constraint
- TOT externality: tradable goods firms do not take into account that pricing decisions affect economy's position on export demand schedule
- *Financial* TOT externality: households do not internalize that their borrowing decisions impact the premium that the economy as a whole needs to pay
- Pecuniary production externality: housing firms do not internalize the effects of their production decisions on land prices

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How do capital controls vary with the pricing paradigm?

Farhi and Werning (2016) meet Gopinath et al. (2020)

- For illustration, turn off housing sector and intermediary friction
- Ex ante capital controls are related to the ex post external constraint, which binds after large depreciations

$$B_2 = \left\{ \begin{array}{c} \underbrace{P^*_{F1}\left[C_{F1} - \omega C^*_1\right] - P^*_{Z1} Z_1}_{\text{net imports}} \\ + \underbrace{\lambda\left(1 + i^*_0\right) B_1}_{\text{"FX" repayments}} + \underbrace{\left(1 - \lambda\right)\left(1 - \varphi_0\right)\left(1 + i_0\right)\frac{E_0}{E_1} B_1}_{\text{domestic currency repayments}} \end{array} \right\} \leq \kappa_{H1} \frac{P_H}{E_1}$$

- So answer depends on exchange rate volatility for PCP versus DCP

How do capital controls vary with the pricing paradigm?

Farhi and Werning (2016) meet Gopinath et al. (2020)

DCP economy has more volatile exchange rates after shocks which alter imports.

- Consider a permanent commodity price decline $\Rightarrow$ permanently lower C_{F1}

$$\textbf{PCP:} \qquad \underbrace{\frac{\alpha_H}{\alpha_F}\frac{E_1 P^*_{F1}}{P_H} C_{F1}}_{\text{import substitution}} - \alpha_H A_1 + \underbrace{\omega C^*_1 \frac{E_1 P^*_{F1}}{P_H}}_{\text{export substitution}} = 0$$

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$$\textbf{DCP:} \quad \underbrace{\frac{\alpha_H}{\alpha_F}\frac{E_1 P^*_{F1}}{P_H} C_{F1}}_{\text{import substitution}} - \alpha_H A_1 = 0$$

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$$\textbf{DCP:} \quad \underbrace{\frac{\alpha_H}{\alpha_F}\frac{E_1 P^*_{F1}}{P_H} C_{F1}}_{\text{import substitution}} - \alpha_H A_1 + \underbrace{\omega C^*_1 \frac{E_1 P^*_{F1}}{P_H} \Theta C^2_{F1}}_{\text{price setting}} = 0$$

- In steady state, final terms take same value in PCP and DCP
- DCP price setting term becomes lower after shocks which reduce C_{F1}

How do capital controls vary with the pricing paradigm?

Farhi and Werning (2016) meet Gopinath et al. (2020)

Ex ante capital controls are optimal for lower initial FX debt under DCP than PCP.

- After adverse commodity price shocks, exchange rate depreciates more under DCP
- Bank constraint may bind under DCP but not PCP

$$\underbrace{\frac{\alpha_H}{\alpha_F}\frac{E_1 P_{F1}^*}{P_H} C_{F1}}_{\text{import substitution}} - \alpha_H A_1 + \underbrace{\text{DCP term}}_{\text{price setting}} + \underbrace{\Psi_{B1}\kappa_{H1}\frac{P_H}{E_1}}_{\text{internalize constraint}} = 0$$

- Internalize the constraint $\Rightarrow$ Depreciate less $\Rightarrow$ Lower AD at $t = 1$
- To shift AD from $t = 0$ to $t = 1$, planner imposes ex ante capital controls

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Does exchange rate flexibility deliver monetary autonomy?

Gabaix and Maggiori (2016) meet Rey (2013)

- Trilemma versus dilemma:
  - Policy rate is technically free
  - But do external shocks move policy rate from price-stabilizing level?
- Deep FX markets ($\Gamma = 0$): UIP wedge is zero
  - Policy rate balances AD and TOT wedges
- Shallow FX markets ($\Gamma > 0$): external shocks destabilize UIP wedge
  - Policy rate addresses UIP wedge, cannot easily balance AD and TOT wedges
  - Ex post capital controls become optimal

Does exchange rate flexibility deliver monetary autonomy?

Gabaix and Maggiori (2016) meet Rey (2013)

Financial TOT externality generates a rationale for ex post capital controls.

- For illustration, turn off borrowing constraint, turn on intermediation friction
- Consider a decline in the foreign appetite for domestic currency debt, $S_1 < 0$
  - Consumption FOC, keeping resource constraint fixed:

Deep: $$\beta I_0 \frac{\alpha_F}{P^*_{F1} C_{F1}} \left[1 + \frac{\alpha_H}{\alpha_F} \left(1 - \frac{C_{H1}}{\alpha_H} \right) \right] = \Phi_1$$

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Shallow:
$$\beta I_0 \frac{\alpha_F}{P^*_{F1} C_{F1}} \left[1 + \frac{\alpha_H}{\alpha_F}\left(1 - \frac{C_{H1}}{\alpha_H}\right)\right] = \Phi_1 + \underbrace{I_0 \Gamma \Omega_1}_{\text{financial TOT externality}}$$

  - $\Gamma\Omega_1 < 0 \Rightarrow$ Role for capital inflow subsidies

Does exchange rate flexibility deliver monetary autonomy?

Gabaix and Maggiori (2016) meet Rey (2013)

Ex post FXI and capital controls should be used together. They reduce the response of the policy rate to foreign appetite shocks.

- FXI can fully absorb the shock: $\Gamma(B_2 + \underbrace{FXI_1 - S_1}_{=0}) = \eta_2 - (1 + i_1^*)$
- But only partial offset is optimal (Fanelli and Straub, 2019; Cavallino, 2019)
- FOC for FXI_1: $\underbrace{\Gamma\Omega_1}_{\text{relax constraint}} = \underbrace{-\frac{\Phi_1}{I_0 I_1}(1-\lambda)\left[\eta_2 - (1 + i_1^*)\right]}_{\text{change in carry profits}}$
- Which establishes the sign: $\Gamma\Omega_1 = \Gamma(1-\lambda)\frac{\Phi_1}{I_0 I_1}\frac{S_1}{2} < 0$
- Integrated model reveals that capital controls should be used alongside FXI

Conclusion

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Can a ban on open FX positions have negative side effects?

Emerging market conundrum

- Emerging markets may have:
  - Less frequent episodes of external FX debt constraints
  - But more frequent use of FXI to mitigate transmission of foreign investor sentiment into domestic currency debt market

Can a ban on open FX positions have negative side effects?

Emerging market conundrum

A ban on open FX positions reduces currency mismatch, vulnerability to external constraints, and the case for any other prudential capital controls.

- Ban domestic-owned intermediaries from borrowing in FX:

$$B_2 = \left\{ \begin{array}{c} \underbrace{P^*_{F1}\left[C_{F1} - \omega C^*_1\right] - P^*_{Z1} Z_1}_{\text{net imports}} \\ + \underbrace{\lambda\left(1 + i^*_0\right) B_1}_{\text{"FX" repayments}} + \underbrace{\left(1 - \lambda\right)\left(1 - \varphi_0\right)\left(1 + i_0\right) \frac{E_0}{E_1} B_1}_{\text{domestic currency repayments}} \end{array} \right\} \leq \kappa_{H1} \frac{P_H}{E_1}$$

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- Depreciate away FX value of inherited debt $\Rightarrow$ No pecuniary AD externality

Can a ban on open FX positions have negative side effects?

Emerging market conundrum

A ban on open FX positions reduces FX market depth, increases vulnerability to foreign appetite shocks, and necessitates ex post FXI.

- The domestic-owned intermediaries no longer respond to higher UIP premia by borrowing more in FX and lending more in domestic currency:

$$\Gamma \left(B_{t+1} + FXI_t - S_t \right) = \mathbb{E}_t[\eta_{t+1} - (1 + i_t^*)]$$

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- The domestic-owned intermediaries no longer respond to higher UIP premia by borrowing more in FX and lending more in domestic currency:

$$\frac{\Gamma}{1-\lambda}\left(B_{t+1} + FXI_t - S_t\right) = \mathbb{E}_t[\eta_{t+1} - (1 + i_t^*)]$$

- Foreign appetite shocks destabilize UIP wedges and macro allocations more

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How do housing fire sales interact with external constraint?

Kiyotaki and Moore (1997) meet Farhi and Werning (2016)

Housing constraint is relaxed by policy rate reduction and exchange rate depreciation.

- Housing constraint in domestic currency:

$$D_{R2}^{Linear} = \left\{ \begin{array}{c} (1+\rho_0)\left[(1+\rho_{-1})\, D_{R0}^{Linear} - P_{R0} L_{-1}\right] \\ +q_0 \left(L_0 - L_{-1}\right) - P_{R1} L_0 - q_1 \left(L_0 - L_1\right) \end{array} \right\} \leq \kappa_{L1} q_1 L_1$$

$$\text{where } P_{Rt} = \frac{\alpha_R E_t P_{Ft}^* C_{Ft}}{\alpha_F \left[L_{t-1} + G\left(1 - L_{t-1}\right)\right]} \text{ and } q_1 = \frac{G'\left(1 - L_1\right) P_{R2} + E_2 \widehat{q}_2}{\left(1 + \rho_1\right)}$$

How do housing fire sales interact with external constraint?

Kiyotaki and Moore (1997) meet Farhi and Werning (2016)

Ex ante capital controls are additionally justified if housing constraint binds ex post and initial FX debt is high.

- Bank constraint may bind because of additional depreciation:

$$0 = \underbrace{\frac{\alpha_H}{\alpha_F} \frac{E_1 P^*_{F1}}{P_H} C_{F1}}_{\text{import substitution}} - \alpha_H A_1 + \underbrace{\omega C^*_1 \frac{E_1 P^*_{F1}}{P_H} \Theta C^2_{F1}}_{\text{price setting}}$$

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$$- \underbrace{\Psi_R A_1 \Theta_R \left[\left(1 + i^*_{-1}\right) B^{Linear}_{R0} - \widehat{P}_{R0} L_{-1} \right]}_{\text{relax housing constraint}}$$

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$$\underbrace{- \Psi_R A_1 \Theta_R \left[\left(1 + i^*_{-1}\right) B^{Linear}_{R0} - \widehat{P}_{R0} L_{-1} \right]}_{\text{relax housing constraint}}$$

$$+ \underbrace{\Psi_{B1} \kappa_{H1} \frac{P_H}{E_1}}_{\text{internalize external constraint}}$$

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Background slides

Financial intermediaries: optimization

- Gabaix and Maggiori (2015)

$$\max \frac{1}{(1+i_t^*)} \frac{q_{t+1}}{E_t} \mathbb{E}_t \left[(1-\varphi_t)(1+i_t) \frac{E_t}{E_{t+1}} - (1+i_t^*) \right]$$

$$\frac{1}{(1+i_t^*)} \frac{q_{t+1}}{E_t} \mathbb{E}_t \left[(1-\varphi_t)(1+i_t) \frac{E_t}{E_{t+1}} - (1+i_t^*) \right] \geq \frac{1}{(1+i_t^*)} \Gamma \left(\frac{q_{t+1}}{E_t} \right)^2$$

- Arbitrage limit:

$$\frac{Q_{t+1}}{E_t} = \frac{1}{\Gamma} \mathbb{E}_t \left[(1-\varphi_t)(1+i_t) \frac{E_t}{E_{t+1}} - (1+i_t^*) \right]$$

- Market clearing:

$$\Gamma \left(\frac{D_{t+1}}{E_t} + FXI_t - S_t \right) = \mathbb{E}_t [\underbrace{(1-\varphi_t)(1+i_t) \frac{E_t}{E_{t+1}}}_{\eta_{t+1}} - (1+i_t^*)]$$

Housing firms: optimization

- Kiyotaki and Moore (1997)

$$\max \mathbb{E}_t [\underbrace{P_{Rt+1} Y^k_{Rt+1}}_{\text{output}} + \underbrace{q_{t+1} L^k_t}_{\text{resale value}}] - \left(1+\theta^k_{Rt}\right)(1+\rho_t) \underbrace{q_t L^k_t}_{\text{purchase}}$$

$$Y^k_{Rt+1} = \left\{ \begin{array}{cc} L^k_t & \text{for } k = Linear \\ G\left(L^k_t\right) & \text{for } k = Concave \end{array} \right\} \text{ where } G' > 0, G'' < 0, G'(0) = 1$$

$$\begin{aligned} D^{Linear}_{R2} &= \left(1+\theta^{Linear}_{R0}\right)(1+\rho_0) D^{Linear}_{R1} + q_1 L^{Linear}_1 \\ &- \left[P_{R1} Y^{Linear}_{R1} + q_1 L^{Linear}_0\right] - T^{Linear}_1 \leq \kappa_{L1} q_{L1} L^{Linear}_1 \end{aligned}$$

- FOCs:

$$\frac{\mathbb{E}_t\left[P_{Rt+1} + q_{t+1}\right]}{\left(1+\theta^{Linear}_{Rt}\right)(1+\rho_t)} \geq q_t$$

$$\frac{G'\left(L^{Concave}_t\right)\mathbb{E}_t\left[P_{Rt+1}\right] + \mathbb{E}_t\left[q_{t+1}\right]}{(1+\rho_t)} = q_t$$

- Market clearing: $L^{Linear}_t + L^{Concave}_t = 1$ and $C_{Rt} = Y^{Linear}_{Rt+1} + Y^{Concave}_{Rt+1}$

PCP and DCP price setting

- $\Lambda_0 = 1$, $\Lambda_1 = \frac{1}{\left(1+i_0^*\right)} \frac{E_0}{E_1}$, and $\Lambda_2 = \frac{1}{\left(1+i_0^*\right)\left(1+i_1^*\right)} \frac{E_0}{E_2}$
- PCP:

$$\max \mathbb{E}_0 \sum_{t=0}^{2} \Lambda_t \left[P_H(j)\left(Y_{Ht}(j) + Y_{Xt}(j)\right) - (1+\phi) W_t N_t(j)\right]$$

$$P_H = (1+\phi)\frac{\varepsilon}{\varepsilon - 1} \frac{\mathbb{E}_0\left[\sum_{t=0}^{2} \Lambda_t \frac{W_t}{A_t}\left(Y_{Ht} + Y_{Xt}\right)\right]}{\mathbb{E}_0\left[\sum_{t=0}^{2} \Lambda_t \left(Y_{Ht} + Y_{Xt}\right)\right]}$$

- DCP:

$$\max \mathbb{E}_0 \left[\sum_{t=0}^{2} \Lambda_t \left[P_H(j) - (1+\phi)\frac{W_t}{A_t}\right] Y_{Ht} \left(\frac{P_H(j)}{P_H}\right)^{-\varepsilon}\right]$$

$$\max \mathbb{E}_0 \left[\sum_{t=0}^{2} \Lambda_t \left[E_t P_X(j) - (1+\phi)\frac{W_t}{A_t}\right] Y_{Xt} \left(\frac{P_X(j)}{P_X}\right)^{-\varepsilon}\right]$$

More on DCP price setting

- Price setting equations:

$$P_H = (1+\phi)\,\frac{\varepsilon}{\varepsilon-1}\,\frac{\mathbb{E}_0\left[\sum_{t=0}^{2}\Lambda_t \frac{W_t}{A_t} Y_{Ht}\right]}{\mathbb{E}_0\left[\sum_{t=0}^{2}\Lambda_t Y_{Ht}\right]} \text{ and } P_X = (1+\phi)\,\frac{\varepsilon}{\varepsilon-1}\,\frac{\mathbb{E}_0\left[\sum_{t=0}^{2}\Lambda_t \frac{W_t}{A_t} Y_{Xt}\right]}{\mathbb{E}_0\left[\sum_{t=0}^{2}\Lambda_t E_t Y_{Xt}\right]}$$

- Depreciation raises wages and domestic price of exports
- P_H increases relative to $P_X \Rightarrow P_X$ falls relative to normalized P_H
- $W_1 = \frac{1}{\alpha_F} E_1 P^*_{F1} C_{F1} \Rightarrow$ Strength of effect depends on C_{F1}

Even more on DCP price setting

- In equilibrium, $Y_{Xt} = \omega \frac{P^*_{Ft}}{P_X} C^*_t$, $Y_{Ht} = C_{Ht} = \frac{\alpha_H}{\alpha_F} \frac{E_t P^*_{Ft}}{P_H} C_{Ft}$, and $W_t = \frac{E_t P^*_{Ft} C_{Ft}}{\alpha_F}$

$$\Rightarrow P_X = P_H \frac{\mathbb{E}_0 \left[\sum_{t=0}^{2} \Lambda_t \frac{W_t}{A_t} Y_{Xt} \right]}{\mathbb{E}_0 \left[\sum_{t=0}^{2} \Lambda_t E_t Y_{Xt} \right]} \frac{\mathbb{E}_0 \left[\sum_{t=0}^{2} \Lambda_t Y_{Ht} \right]}{\mathbb{E}_0 \left[\sum_{t=0}^{2} \Lambda_t \frac{W_t}{A_t} Y_{Ht} \right]} = P_H \frac{X_1}{X_2} \frac{X_3}{X_4}$$

where we define:

$$X_1 = \mathbb{E}_0 \left[\sum_{t=0}^{2} \frac{1}{\Pi_{s=1}^{t} \left(1+i^*_{s-1}\right)} \frac{1}{A_t} \left(P^*_{Ft}\right)^2 C^*_t C_{Ft} \right] \qquad X_3 = \mathbb{E}_0 \left[\sum_{t=0}^{2} \frac{1}{\Pi_{s=1}^{t} \left(1+i^*_{s-1}\right)} P^*_{Ft} C_{Ft} \right]$$

$$X_2 = \mathbb{E}_0 \left[\sum_{t=0}^{2} \frac{1}{\Pi_{s=1}^{t} \left(1+i^*_{s-1}\right)} P^*_{Ft} C^*_t \right] \qquad X_4 = \mathbb{E}_0 \left[\sum_{t=0}^{2} \frac{1}{\Pi_{s=1}^{t} \left(1+i^*_{s-1}\right)} \frac{1}{A_t} \left(E_t P^*_{Ft} C_{Ft}\right)^2 \right]$$

FOCs in wedges (1)

- Exchange rate:

$$\underbrace{\alpha_H \tau_{Ht}}_{\text{Stabilize demand for home goods}} = \underbrace{\begin{array}{c} -\mathbb{I}^{PCP} \cdot \left\{ \omega C_t^* \frac{\alpha_F}{C_{Ft}} \tau_{Xt}^{PCP} \right\} \\ -\mathbb{I}^{DCP} \cdot \left\{ \mathbb{E}_0 \left[\sum_{t=0}^{2} \beta^t \omega C_t^* \frac{\alpha_F}{C_{Ft}} \tau_{Xt}^{DCP} \right] \frac{1}{\beta^t \pi_t} \frac{E_t}{P_X} \left(-\frac{\partial P_X}{\partial E_t} \right) \right\} \end{array}}_{\text{Optimize TOT on export goods}}$$

$$+ \underbrace{\frac{\Psi_{Bt}}{\beta^t \left(1 + i_{t-1}^*\right)} \kappa_{H1} \frac{P_H}{E_t}}_{\text{Relax bank constraint}} \tag{1}$$

- FX intervention:

$$\underbrace{\Gamma \Omega_t}_{\text{Lower premium today}} + \underbrace{(1-\lambda)\, \mathbb{E}_t \left[\frac{\Phi_{t+1} + \Psi_{Bt+1}}{\prod_{s=0}^{t} I_s} \frac{P_{Ft+1}^* C_{Ft+1}}{\alpha_F} \tau_{\Gamma t+1} \right]}_{\text{Change in carry cost}}$$

$$\underbrace{+(1-\lambda)\, \Gamma \mathbb{E}_t \left[\Omega_{t+1} \frac{P_{Ft+1}^* C_{Ft+1}}{\alpha_F} \tau_{\Gamma t+1} \right]}_{\text{Change in premium tomorrow}} = 0 \tag{2}$$

FOCs in wedges (2)

- UIP wedge:

$$\underbrace{\Omega_t}_{\text{Ability to borrow more today}} = \underbrace{(1-\lambda)\frac{\Phi_{t+1}+\Psi_{Bt+1}}{\Pi_{s=0}^{t} I_s}\left(B_{t+1}+FXI_t\right)}_{\text{Higher repayments tomorrow}} \pm \underbrace{\frac{1}{\pi_{t+1}}\Lambda E_{t+1}}_{\text{Contingency check}}$$
$$+ \underbrace{(1-\lambda)\,\Omega_{t+1}\Gamma\left(B_{t+1}+FXI_t\right)}_{\text{Higher premium tomorrow owing to rollover needs}} \quad (3)$$

- Consumption:

$$\frac{\alpha_F}{P_{Ft}^{*}C_{Ft}}\left[1+\frac{\alpha_H}{\alpha_F}\tau_{Ht}\right] - \mathbb{I}^{DCP}\cdot\left\{\mathbb{E}_0\left[\sum_{t=0}^{2}\beta^t\omega C_t^{*}\frac{\alpha_F}{C_{Ft}}\tau_{Xt}^{DCP}\right]\frac{1}{\beta^t\pi_t}\frac{1}{P_{Ft}^{*}}\frac{1}{P_X}\frac{\partial P_X}{\partial C_{Ft}}\right\}$$
$$= \beta\mathbb{E}_t\left\{\left(\frac{\alpha_F\left(1+i_t^{*}\right)}{P_{Ft+1}^{*}C_{Ft+1}}+(1-\lambda)\,\tau_{\Gamma t+1}\right)\left[1+\frac{\alpha_H}{\alpha_F}\tau_{Ht+1}\right]\right\}+\frac{\Psi_{Bt}}{\beta I_{t-1}}+\left(\frac{1}{\beta}\right)^t\Gamma\Omega_t$$
$$-\mathbb{I}^{DCP}\cdot\left\{\mathbb{E}_0\left[\sum_{t=0}^{2}\beta^t\omega C_t^{*}\frac{\alpha_F}{C_{Ft}}\tau_{Xt}^{DCP}\right]\mathbb{E}_t\left[\frac{\left(1+i_t^{*}\right)+(1-\lambda)\frac{\tau_{\Gamma t+1}}{\frac{\alpha_F}{P_{Ft+1}^{*}C_{Ft+1}}}}{\beta^t\pi_{t+1}}\frac{1}{P_{Ft+1}^{*}}\frac{1}{P_X}\frac{\partial P_X}{\partial C_{Ft+1}}\right]\right\}$$
(4)

FOCs in wedges (3)

- Land usage:

$$\underbrace{\beta\tau_{R1}}_{\text{Minimize housing distortion}} = \mathbb{E}_0\left[\Psi_{R1}\left\{\begin{array}{c}\underbrace{\left(\chi_1\widehat{q}_0-\widehat{P}_{R1}-\widehat{q}_1\right)}_{\text{Hedging motive}}\\ +\underbrace{\frac{\partial\left(\chi_1\widehat{q}_0\right)}{\partial L_0^{Linear}}\left(L_0^{Linear}-L_{-1}^{Linear}\right)}_{\text{Effect on period-0 land price}}-\underbrace{\frac{\partial\widehat{P}_{R1}}{\partial L_0^{Linear}}L_0^{Linear}}_{\text{Effect on rent}}\end{array}\right\}\right] \tag{5}$$

$$\begin{aligned}\underbrace{\beta\tau_{R2}}_{\text{Minimize housing distortion}} &= \underbrace{\Psi_{R1}\widehat{q}_1\left(1-\kappa_{L1}\right)}_{\text{Housing constraint}}+\underbrace{\Psi_{R1}\frac{\partial\widehat{q}_1}{\partial L_1^{Linear}}\left(\left(1-\kappa_{L1}\right)L_1^{Linear}-L_0^{Linear}\right)}_{\text{Tightening of constraint}}\\ &\quad+\frac{1}{\pi_1}\mathbb{E}_0\left[\Psi_{R1}\underbrace{\frac{\partial\left(\chi_1\widehat{q}_0\right)}{\partial L_1^{Linear,s}}\left(L_0^{Linear}-L_{-1}^{Linear}\right)}_{\text{Effect on period-0 land price}}\right]\end{aligned} \tag{6}$$